

## **Final Performance Report for NAG5-9283**

**Date:** October 28, 2002  
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**NASA Grant No:** NAG5-9283  
**Title:** *The Evolution of Disks and Winds in Dwarf Nova Outbursts*  
– *FUSE*  
**STScI Project No:** J0248  
**Period of Performance:** 04/15/99 – 04/14/02

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This project was a project to study the FUV spectra of two proto-typical dwarf novae -- U Gem and SS Cygni -- through an outburst cycle. The luminosity of the boundary layer in the two systems, as evidenced by earlier EUVE observations, is different in the two systems. Our intensive study of the two systems was intended to (1) probe the ionization and kinematic structure of the wind as a function of system brightness, (2) isolate the contributions of the disk to the FUV spectra, and (3) examine physical conditions and abundances of material just being accreted onto the disk from the secondary.

The U Gem and SS Cyg observations took place in March and October 2000, respectively. The data obtained with FUSE was of excellent quality. Analysis of the both observations is now essentially complete, although some modeling of the SS Cyg spectra is ongoing, as we complete an ApJ manuscript on this object.

Our main results for U Gem are as follows: The plateau spectra have continuum shapes and fluxes that are approximated by steady state accretion disk model spectra with an accretion rate  $7 \times 10^{-9}$  Msolar/yr. The spectra also show numerous absorption lines of H I, He II, and 2-5 times ionized transitions of C, N, O, P, S, and Si. There are no emission features in the spectra, with the possible exception of a weak feature on the red wing of the O VI doublet. The absorption lines are narrow (FWHM~500 km/s), too narrow to arise from the disk photosphere, and at low velocities ( $\leq 700$  km/s). The S VI and O VI doublets are optically thick. The absorption lines in the plateau spectra show orbital variability: in spectra obtained at orbital phases between 0.53 and 0.79, low-ionization absorption lines appear and the central depths of the preexisting lines increase. The increase in line absorption occurs at the same orbital phases as previously observed EUV and X-ray light-curve dips. If the absorbing material is in (near-) Keplerian rotation around the disk, it must be located at large disk radii. The final observation occurred when U Gem was about 2 mag from optical quiescence. The spectra are dominated by emission from an  $\sim 43,000$  K, metal-enriched white dwarf (WD). The inferred radius of the WD is  $4.95 \times 10^8$  cm, close to that observed in quiescence. Allowing for a hot heated region on the surface of the WD improves the fit to the spectrum at short (less than 960 Å) wavelengths.

Our main results for SS Cyg are as follows: The first two of four observations of SS Cyg show disk dominated spectra with accretion rates of order  $10^{-8}$  Msolar/yr. Except for narrow interstellar features (atomic and molecular H), the lines are all broad consistent with a disk or wind origin. The O VI line in the spectra is mostly of wind origin as detailed modeling with our Monte Carlo code (developed in part using funds from this project) show. The continua from spectra in observations 3 and 4, observed during the decline phase, are not well fit with steady-state disks, and show considerable resemblance to quiescent spectra obtained with HUT. The most probable interpretation for the emission features seen in the spectrum in the last two observations is that they arise from a photo-illuminated choronosphere above the disk, rather than a wind.

Results from the project have been or are being documented in a variety of publications in the astronomical literature:

Froning, C. S., Long, K. S., Drew, J. E., Knigge, C., & Proga, D. 2001, "FUSE Observations of U Geminorum during Outburst and Decline," *ApJ*, 562, 963

Long, K. S. & Knigge, C. 2002, "Modelling the spectral signatures of accretion disk winds in cataclysmic variables", *ASP Conf. Ser. 261: The Physics of Cataclysmic Variables and Related Objects*, 327

Froning, C. S., Long, K.S., Drew, J. E., Knigge, C., Proga, D., & Mattei, J.A. 2002, "The evolution of disks and winds in dwarf novae outbursts", *ASP Conf. Ser. 261: The Physics of Cataclysmic Variables and Related Objects*, 337

Long, K. S. & Knigge, C. 2002, "Modeling the Spectral Signatures of Accretion Disk Winds: A New Monte Carlo Approach", *ApJ*, in press

Long, K. S., Froning, C. S., Knigge, C., Drew, J. E. 2003, "FUSE Observations of SS Cygni during Outburst and Decline", *ApJ*, in prep

We view this project as a success.

# FEDERAL CASH TRANSACTIONS REPORT

(See instructions on the back. If report is for more than one grant or assistance agreement, attach completed Standard Form 272A.)

OMB APPROVAL NO. 0348-0003

## 2. RECIPIENT ORGANIZATION

Name: Space Telescope Science Institute

Number 3700 San Martin Drive  
and Street:

City, State Baltimore, MD 21218  
and ZIP Code:

1 Federal sponsoring agency and organizational element to which this report is submitted

NASA Goddard Space Flight Center  
Accounting Branch Code 151-2  
Greenbelt MD 20771

4 Federal grant or other identification number

NAG5-9283

5 Recipient's account number or identifying number

J0248

6 Letter of credit number

80005122

7 Last payment voucher number

n/a

Give total number for this period

8 Payment Vouchers credited to your account

9 Treasury checks received (whether or not deposited)

## 10. PERIOD COVERED BY THIS REPORT

## 3. FEDERAL EMPLOYER IDENTIFICATION NO.

86-0138043

FROM (month, day, year)

4/15/00

TO (month, day, year)

4/14/02

## 11. STATUS OF

FEDERAL

CASH

(See specific instructions on the back)

a. Cash on hand beginning of reporting period

\$

b. Letter of credit withdrawals

68,748.36

c. Treasury check payments

0.00

d. Total receipts (Sum of lines b and c)

68,748.36

e. Total cash available (Sum of lines a and d)

68,748.36

f. Gross disbursements

68,748.36

g. Federal share of program income

h. Net disbursements (Line f minus line g)

68,748.36

i. Adjustments of prior periods

j. Cash on hand end of period

\$

## 12. THE AMOUNT SHOWN ON LINE 11j, ABOVE, REPRESENTS CASH REQUIREMENTS FOR THE ENSUING

Days

## 13. OTHER INFORMATION

a. Interest income

\$

b. Advances to subgrantees or subcontractors

\$

## 14. REMARKS (Attach additional sheets of plain paper, if more space is required)

Total award amount \$69,000.00

FINAL 272 report for J0248

## 15.

## CERTIFICATION

I certify to the best of my knowledge and belief that this report is true in all respects and that all disbursements have been made for the purpose and conditions of the grant or agreement.

AUTHORIZED

CERTIFYING

OFFICIAL

SIGNATURE

TYPED OR PRINTED NAME AND TITLE

Amy Garrett Power  
Accountant  
apower@stsci.edu

DATE REPORT SUBMITTED

02/10/2003

TELEPHONE (Area Code, Number, Extension)

410-338-4801

THIS SPACE FOR AGENCY USE

Space Telescope Science Institute  
Final Property/Inventory Report for Grant Number  
NAG5 – 9283  
STScI Project No.: J0248  
As of 11/01/02

For dollar values greater than 5,000.00 and less than 100,000,000.00

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Negative Report

# NASA GRANTEE NEW TECHNOLOGY SUMMARY REPORT

NASA requires each research grantee, research contractor, and research subcontractor to report new technology to the NASA Commercial Technology Office. For that purpose, the following reports and corresponding schedules are provided:

<u>Title of Report</u>	<u>Form Number</u>	<u>Timetable</u>
New Technology Disclosure	NASA Form 1679	The grantee discloses <i>each</i> discovery of new technology individually, at the time of its discovery
NASA Grantee New Technology Summary Report (checkmarked "Interim")	NASA C-3043	For multi-year grants, the grantee summarizes the previous year's disclosures on an annual basis. The first Interim New Technology Summary Report is due exactly 12 months from the effective date of the grant. Future reports are due annually, thereafter.
NASA Grantee New Technology Summary Report (checkmarked "Final")	NASA C-3043	The grantee submits a cumulative summary of all disclosed technologies. The Final New Technology Summary Report is submitted immediately following the grant's technical period of performance.

Grantee Name: Dr. Knox Long

Grantee Address: Space Telescope Science Institute  
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Telephone No.: (410) 338-4586

NASA Grant No: NAG5-9283 Grant Completion Date: 04/14/02

NASA GM: George Sonneborn Report Submitted by: Joy Hayes McQuay

New technology should be reported whether or not it is or may be patentable.

Large business contractors and subcontractors must disclose all reportable items to NASA. Reportable items as used in NASA contracts (or subcontracts) with large businesses means any invention, discovery, improvement, or innovation, whether or not patentable, conceived or first actually reduced to practice in the performance of work under a NASA contract (or subcontract). Reportable items include, but are not limited to, new processes, machines, manufactures, and compositions of matter, and improvements to, or new applications of, existing processes, machines, manufactures, and compositions of matter. Reportable items also include new computer programs, and improvements to, or new applications of, existing computer programs, whether or not copyrightable.

Small business, nonprofit organization, and college and university contractors and subcontractors must disclose all subject inventions to NASA. Subject inventions as used in NASA contracts (or subcontracts) with other than large businesses means any invention or discovery which is or may be patentable and is conceived or first actually reduced to practice in the performance of work under a NASA contract (or subcontract). Subject inventions include any new process, machine, manufacture, or composition of matter, including software, and improvements to, or new applications of, existing processes, machines, manufactures, and compositions of matter, including software.

**Subject to approval by contractors (or subcontractors) who retain or obtain title to subject inventions or reportable items, all such reported items are evaluated for publication in NASA Tech Briefs. If an item is published in NASA Tech Briefs, the innovator receives a monetary award from NASA.**

## General Information

- **New Technology Items**

- **Grant Subcontractors**

**NONE**

Date of Award:

Date of Award:

Date of Award:

- **Certification**

I certify that active and effective procedures ensuring prompt identification and timely disclosures of reportable new technology items have been followed. Furthermore, I certify that all new technology items required to be disclosed and conceived during the period identified on this form have been disclosed to NASA.

Joy Hayes McQuay

### Sponsored Programs Administrator I

Name and Title of Authorized Official

Signature and Date